

Nadiia Potapova*Vasyl' Stus Donetsk National University, Ukraine**E-mail: potapova.nadin@gmail.com**ORCID: <https://orcid.org/0000-0003-4566-4102>**ResearcherID: L-8928-2018***Lyudmila Volontyr***Vinnytsia National Agrarian University, Vinnytsia, Ukraine**E-mail: milavolontyr@ukr.net**ORCID: <https://orcid.org/0000-0001-9022-9332>**ResearcherID: L-8944-2018*

System approach in modeling the processes of functioning of agro-logistic systems

Abstract

Purpose. The article is devoted to the issues of system research in the field of agricultural logistics. The necessity of agricultural logistics research on the basis of a systematic approach, the essence of which is manifested in the idea of studying the relationship between the individual parts of the logistics object with a mathematical model. The main principles of the system approach in the management of agricultural logistics systems are recognized as: consistency, decomposition, modeling, uncertainty, efficiency, consistency, sufficiency, purposefulness, alternativeness. The integrity and uniqueness of agricultural logistics systems is due to the cause-and-effect relationship, which manifests itself as a purposeful action of individual elements and subsystems and has a sustainable economic structure. The structural characteristics of agricultural logistics systems are highlighted in the process of synthesis of their components from the highest to the lowest level of the hierarchy, on the basis of which the conclusion about the hierarchical construction of agricultural logistics systems is made. It was found that the formalization of the model of agricultural logistics system is due to the finite level of specification of the number of parameters, blocks and constraints. Most of the properties of agricultural logistics system are probabilistic. Variability in the behavior of the agricultural logistics system arises due to external influences, the critical level of which exceeds the expected value. Thus, changes in the characteristics of each level of the agricultural logistics system must be coordinated with each other. A statement is formed about the completeness of decision-making at different levels of the hierarchy of the system, which results in the implementation and coordination of functions to achieve the goal. The behavior of the system is formed on the basis of the allocation of a particular alternative from a particular set of alternatives in accordance with the response to external influences. *Methodology.* The study is based on the use of such general scientific methods as: analysis, synthesis and analogy. For the system approach it is important to determine the structure of the system – a set of relations between the elements of the system, reflecting their interaction. The purpose of the work is to study the principles of the system approach in the management of processes and systems of agricultural logistics. *Practical implications.* The practical value of the work lies in identifying the main systemic cause-and-effect patterns emerging in the agro-industrial complex environment and potentially determining the structure of agricultural logistics systems. The agro-industrial complex is characterized by increasing rates. Grain and oilseed crops, vegetable oils and meal are the basis of external supplies, which in total account for more than 80% of the volume. One of the main problems of the agricultural sector is logistics, which must solve the issues of preservation of harvested products, transportation and sales to the end consumer. The functioning of agricultural logistics is reflected in the export potential of Ukraine, and at the same time it replenishes the budget. The share of exports of food products and agricultural products in the total exports of Ukraine in 2020 was 45.1%. Grain crops (42.4%); oils (25.6%); oilseeds (8.1%) account for the share of exports. There is a real need for terminals, both maritime and river terminals. These are all system characteristics of agricultural logistics. A systematic study of agricultural logistics is a key element on the basis of which the practical organization of these systems should be

Keywords

Agricultural logistics, agricultural logistics system, material resources, system approach, principles of system approach

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considered as a source of long-term growth of the agricultural sector. *Value/originality*. The peculiarity of this study is the transformation, implementation of the basic principles of the system approach and the theory of systems to the industry specifics of agro-logistics. On the basis of influencing system factors of agricultural production, the properties of agro-logistic systems and their targets are highlighted and generalized.

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1 Introduction

The competitive environment in the agricultural sector is changing for several reasons, one of which is the impact of the logistics component in the management of enterprises and the formation of supply chains of agricultural products. Agrologistics as a science includes the study of management processes of material, information and related financial flows occurring in the market of agricultural products and distributed from the producer to the consumer. Agro-logistics covers all activities of an enterprise: from the processes of planning the cycle of agricultural production to its sales to end consumers. The development of effective agro-logistics includes effective cost control and storage of materials and finished products, providing information support, developing a transport scheme of supply, supply service, creating a distribution network and much more.

Modern agro-logistics functions on integrated system links. Participants provide a coordinated mechanism of aggregate activity that ensures maximum efficiency. Integration of agro-logistics provides an appropriate level of competitiveness of agricultural products and at the same time serves as one of the mechanisms to minimize costs and form the supply of products at lower prices. The authors achieve the goal by avoiding some supply risks due to the coordinated interaction of all participants in the agro-logistic chain, and not at the expense of reducing the quality of products (Gritsenko, 2014). The significant export potential of Ukraine determines the improvement and development of agro-logistics, the functioning of which should be aimed at ensuring time-independent supply of agricultural products with minimal costs.

Specialists cannot solve the issues of logistics management without appropriate financial support, even if they belong to either small agricultural formations or significant integrated agricultural holdings. With the help of the EU in selling agricultural products on European markets, systematic solutions in agro-logistics will ensure the development of effective promotion of product flows with the maximum expected level of sales revenues.

Ukraine has the potential to obtain stable growth rates of agricultural products supply due to a number of favorable geographical, climatic and resource conditions. The key factor is the success in growing

agricultural products and the effectiveness of actions to preserve and deliver the crop to the end consumer during the previous and current marketing years. Consequently, agro-logistics aggravates the problem of implementation of system solutions related to both the theoretical and methodological principles of agricultural management and the possibilities of their practical implementation at the present time.

2 The system approach in the management of agro-logistic systems

The modern agro-logistic concept corresponds to the method of the system approach. In the context of integration and globalization of trade relations, the conceptual provisions of agro-logistics position it as a paramount component in obtaining the maximum effect of the expected opportunities in the agricultural sector.

As for today, the agricultural sector of Ukraine has many enterprise producers, each of them has its legal basis and has different degrees of integration of management. According to the State Statistics Office of Ukraine, on the 1st of November 2019, the number of agricultural producers in Ukraine was 48,504, farms occupied 66.9% (the largest share) (Statistical collection Agriculture of Ukraine for 2019). As of November 2019, the Ministry of Agrarian Policy of Ukraine allocated €6,66645.0 thousand. They allocated €258,0409.1 thousand under the main programs to support the development of the Agro-industrial complex. In particular, for financial support of measures in the Agro-industrial complex by reducing the cost of loans – 104085.3 thousand, which were sent to the regions and used – €103 249.3 thousand, for financial support for the development of farms allocated €152,222.0 thousand (Information and analytical portal of Ukraine).

Increasing rates specify agribusiness in 2019 as well. Thus, according to the Ministry of Agrarian Policy and Food of Ukraine, in 2020, the agricultural product index was 88.5%. Cereals and oilseeds, vegetable oils, and meals are the base of external supplies, which account for over 80% of the volume. There is an increase in such product groups as meat – by 17%, dairy products – by 6%, fruits, and berries – by 11%, products of processed vegetables and fruits – by 22% (Information and analytical portal of Ukraine).

One of the main problems of the agricultural sector is logistics, which is primarily associated with the preservation of harvested tonnage, its transportation and sale to the end consumer (Official site of the Ukrainian Agrarian Confederation). This reflected the functioning of agro-logistics in Ukraine's export potential and budget replenishment. In foreign trade in food and agricultural products for January-December 2020, the share of food and agricultural products exports in total exports was 45.1%. The part of exports of food products and agricultural products in 2020 for certain groups of goods was cereals – 42.4%; oils – 25.6%; oilseeds – 8.1%; cakes, solid waste from the extraction of vegetable fats and oils – 6.3%.

The need for terminals, both sea and river, is reasonable. With the need for simultaneous storage of more than 60 million tons of grain, the existing capacities in Ukraine amount to 34 million tons. The lack of storage facilities and warehouses forces producers to sell harvested products from the fields, disregarding prices and making less profit than expected. Non-compliance with storage conditions reduces the quality of products, which ultimately manifests itself in the final revenue from sales. Thus, agro-logistics requires a systematic approach in solving the issues of financing logistics projects and ensuring a smooth cycle of material flows with the final sale of agricultural products.

Logistics has historically deep roots, originating from the Roman Empire as a military discipline (Gadzhinsky, 2005). The modern interpretation of logistics is a science based on the theory of flow management in operational management. The main elements of management are the operations performed in the enterprise, connected in a chain, determined by the sequence and functional purpose. Here, logistics acts as an integrator of relations between sections of the chain of operations. In this paper, it is possible to perceive logistics as an ideology of coordinated and optimal management from the origin of the flow to the place where it ends. Logistics is a science that studies the theory and practice of managing material and related informational flows (Gadzhinsky, 2005; Dovba, Chornopyska, 2004; Krykavskiy, Chukhray, Chornopyska, 2006). The object of logistics is the material flow, which is the basis of material production and is a source of consumer value. The authors link and explore the uncertainty and value of material flow with the movement of information and financial flows that accompany this flow. E.V. Krykavsky emphasizes the perception of logistics as effective material flow management, considering the points of origin and delivery to the end-user (Chornopyska, 2006).

The authors consider agro-logistics as a sectoral, functional subsystem in the overall management system of a particular enterprise, region, state. In

(Kosareva, (2008), T.V. Kosareva defines the logistics of agriculture as a science and practice of managing economic flows in production, distribution of exchange, and consumption of agricultural products. O.P. Velychko emphasizes the peculiarities of the biological nature of logistics flows (Velichko). It is possible to agree with all the statements, even if there are many controversial issues. In modern research of agro-logistics, the primary source is the formation of material flow, which can be raw materials, finished products, semi-finished products, biological assets, services generated during agricultural operations. The authors of the work consider it as things and materials (fertilizers, seeds, plant protection products, fodder, machinery and more) and as "living goods" (plants, animals and other biological assets). The specifics of the relationships formed in agro-logistics are due to many factors. It is necessary to highlight some of them (Potapova, 2010).

1. Priority of land resources. Land is the primary resource for conducting business activity, and it additionally affects technical and economic components of logistics operations and property relations formed within Agro-logistics systems. The number of sown areas plays an important role in predicting the volume of gross harvest. In 2019, the area of agricultural land in Ukraine was 41 310.9 thousand hectares, including arable land – 32 757.3 thousand hectares, hayfields – 2 283.9 thousand hectares, pastures – 5 250.3 thousand hectares, perennial plantations – 852.7 thousand hectares.

2. The presence of structural changes in farms. Agroholdings significantly affect the development of agriculture, mainly in export activities (increasing exports), reducing costs, increasing capitalization, attracting investors. This effect can be achieved through the integration of production and supply chains.

3. Influence of environmental risks. The dependence of field work on the weather necessitates precise administration in the implementation of the operational schedule in accordance with the technological charts of cultivation and harvesting. The high profitability of some crops (sunflower, rapeseed, corn, and others), achieved without regard to the ecological balance and quality of land resources, attracts producers with significant profits.

4. The presence of seasonal fluctuations in supply and demand in the market of agricultural products. The seasonality of agricultural production determines the observance of optimal temporal regulations for the coordination of operations within the marketing year. Significant quantities of simultaneously arriving products require an effective system of storage and distribution in own and leased warehouses.

5. Price disparity between the cost of the final product and the means of production. Significant imbalance of the cost of agricultural and industrial

products requires accurate coordination of financial flows, accounting for budget planning, cost recovery, constant monitoring and forecasting of prices for seeds, energy, plant protection products, feed and services.

6. Significant dependence on transport infrastructure. Organization of ways to deliver agricultural products requires the intermodal option of transportation over long distances. Fluctuations in the price of smoothies during the sowing season force farmers to take loans at the expense of the future harvest.

7. Significant influence of state regulation. In many areas of agricultural business there is the influence of the "invisible hand of the state", which is manifested in the encouragement of lending to individual enterprises, the introduction of quotas, permits, state support in the form of subsidies, etc.

The authors apply agro-logistics to major challenges.

- compliance with international quality standards in food safety;
- transition to innovative management models in supply chains
- introduction of the latest technologies of collection, processing, transportation, storage, and distribution of agricultural products
- increasing the level of competitiveness of agricultural products in domestic and foreign markets;
- increasing the level of investment attractiveness of the agricultural sector;
- growth of profits of agricultural producers.

The material flow moves within the agro-logistic system, defined at specific levels of the economy: macro-level (within the enterprise), meso-level (within the region), macro-level (within the state), mega-level (global space).

The agro-logistic system should represent an economic system defined by the elements and processes of material flow management in agriculture, with established structured links and logistic goals.

The agro-logical system functions in accordance with the principles of the system approach and system analysis. The use of the systems approach in agro-logistics involves identifying the main characteristics, the management of which will allow the system to adapt to changes in the environment and maintain a stable, steady mode of operation. Indispensable properties of agro-logistic systems are:

1. complexity characterized by the number of elements, subsystems, methods of interaction;
2. hierarchy, which reflects the rule of order of the lower-level elements concerning the higher-level components of logistics management;
3. emergence, the ability of the system to perform a function of purpose that is not approachable to reach by its single parts;
4. structured pattern implies internal organizational structure;

5. the dynamics of development involves changing the characteristics of the system over time;

6. information uncertainty reflected in the risks of behavior under the influence of the external environment;

7. adaptability, the ability to change its structure and to conduct a variety of behavioral choices under the influence of the external environment;

8. self-organization, the ability to form alternative forms with a higher level of organization;

9. synergy, the ability to get a significant effect from the processes of self-organization and self-reproduction.

The fundamental principles of the systems approach in the management of agricultural systems are (Potapova, 2014):

- The principle of systematization. Processes and elements that define the system have unique causal relationships manifested in the properties of a single whole. The system has such properties that none of its chains will implement them in the event of its destruction.
- The principle of decomposition. The structure of agro-logistics and agro-logistic chains involves its component synthesis from higher to lower levels.
- The principle of modeling, which characterizes that each agricultural system must have a last level of formalization, i.e., a certain number of parameters, blocks, and constraints must describe its model.
- The principle of uncertainty lies in the probabilistic nature of the properties of the agricultural system.
- The principle of effectiveness is changing the behavior of the agricultural system. It is necessary to cause external influences that exceed the critical value.
- The principle of coherence. According to this rule, specialists should jointly coordinate each level of the agro-logistical system characteristic changes.
- The principle of complementarity and sufficiency is to determine the completeness of decisions made at different hierarchy levels.
- The principle of purposefulness characterizes the functionality of the agro-logistics system to pursue the goal.
- The alternative (multivariate) choice principle. It is associated with the capacity for defining behavior following the reaction to external influences and purposefulness.

3 Conclusions

The modern leader must have a systemic mindset. Systems thinking not only contributed to the development of new ideas about the organization (in particular, special attention was paid to the integrated nature of the enterprise, as well as

the importance and significance of information systems), but also ensured the development of useful mathematical tools and techniques that greatly facilitate managerial decision-making, planning and control. Thus, the systematic approach allows the manager to comprehensively assess any industrial and economic activity and the activities of the management system at the level of specific characteristics. This will help to analyze any situation within a single system, to identify the nature of input, process and output problems. Applying a systems approach allows for the best possible organization of decision-making at all levels in the management system.

Integration properties of agricultural logistics systems allow to achieve the main goal of logistics: to deliver products of required quality in the right quantity at the right time to the right place with

minimal costs. Thus, an agrol-ogistic system construction passes all stages of process management according to the scheme: purpose → strategy → technology → business → processes → logistic functions → operations. Agricultural logistics systems are oriented to both the size of an enterprise and its purpose. Therefore, maintaining equilibrium processes in the system and ensuring its sustainable functioning depends on ensuring a certain level of administration. The formation of Ukraine's export potential is inextricably linked to the development and implementation of modern material flow management models that rely on agricultural logistics to minimize aggregate costs. The greatest effect of agricultural logistics is achieved in integrated supply chains, which are implemented on the basis of large agricultural holdings through the integration of raw material bases and industrial processing enterprises.

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